7.0 COMPARISONS WITH OTHER STUDIES

The environmental sampling results of the CAP Study may be compared to those from other studies. In particular, comparisons to the earlier CAP Pilot Study, the HUD Abatement Demonstration Project, and other studies assessing the efficacy of an abatement procedure seem most applicable. Section 7.1 compares the results from the pilot and full CAP studies. A comparison to the HUD Demonstration results is presented in Section 7.2; and the CAP results are compared to the results of other abatement efficacy studies in Section 7.3.

7.1 COMPARISON OF CAP STUDY DATA AND CAP PILOT STUDY DATA

The CAP Pilot Study investigated field, laboratory, and statistical analysis procedures planned for the CAP Study. The CAP Pilot Study samples were collected in May 1991, as compared to the CAP Study sampling in March and April 1992. A complete discussion on the Pilot Study is available in another report (EPA, 1995a).

Of the six residential houses surveyed in the Pilot Study, five were revisited in the CAP Study. Figure 7-1 displays the differences for those five houses between the CAP Pilot and full CAP study geometric mean lead loading results, by sample type. Similar plots for lead concentration and dust loading are presented in Figures 7-2 and 7-3, respectively. Each line segment in the figures represents the change in lead loading for a particular house and sample type. For example, the vacuum floor lead loading results were higher in the full study than in the Pilot for all houses except House 51. In the figure, this is evidenced by the appropriate line segments rising from left to right.

As the figures suggest, when comparing the CAP Pilot and the CAP Study results, there is no single pattern of change across the various sample types. For example, a particular house may have higher air duct lead loadings in the CAP Study than in the

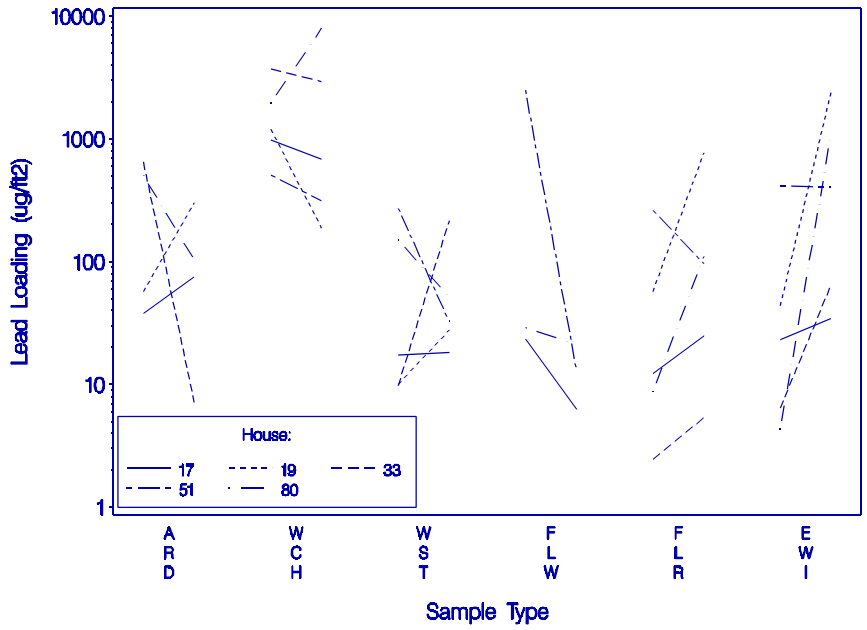

Figure 7-1. Comparison of CAP Pilot Study and CAP Study results: unit geometric mean lead loading (µg/ft²) by sample type.

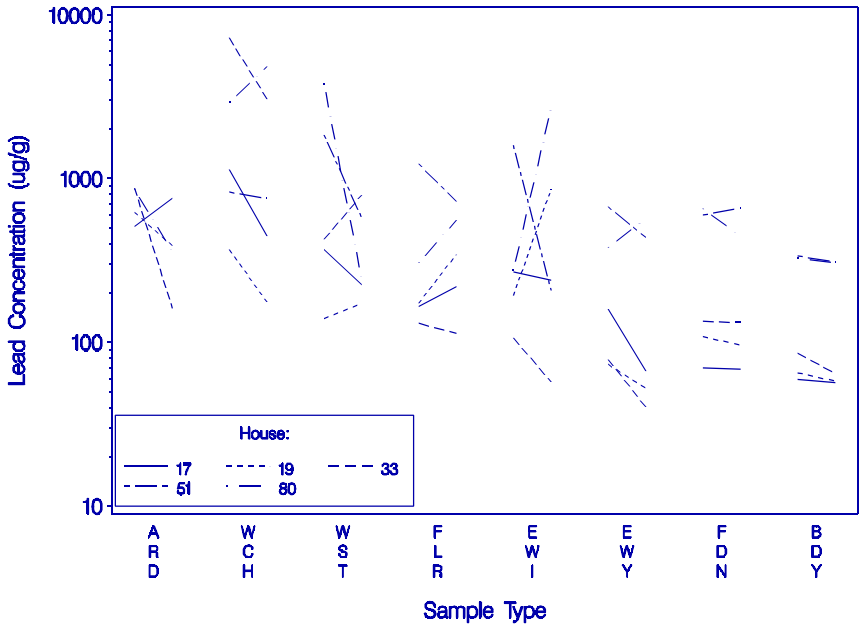

Figure 7-2. Comparison of CAP Pilot Study and CAP Study results: unit geometric mean lead concentration (µg/g) by sample type.

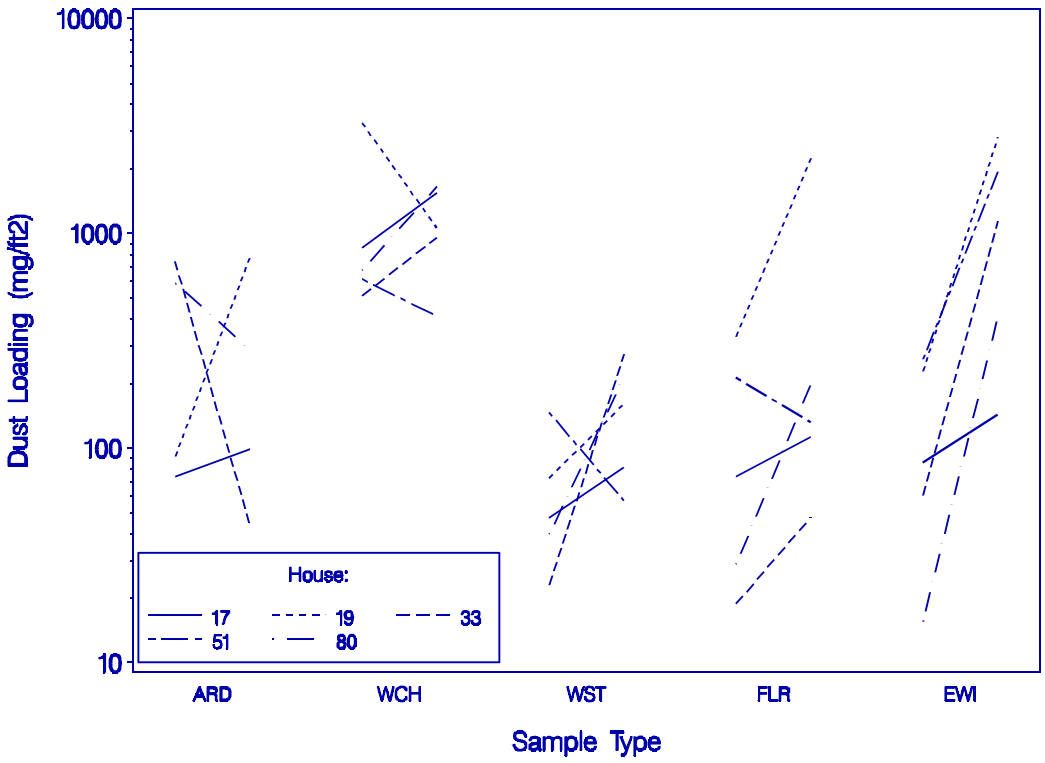

Figure 7-3. Comparison of CAP Pilot Study and CAP Study results: unit geometric mean dust loading (mg/ft^2) by sample type.

Pilot, but lower window channel lead loadings. The vacuum floor and interior entryway changes are the most similar house to house, especially for the lead loading and dust loading results. The window channel and window stool results, in turn, were the least consistent. Not surprisingly, the soil lead concentration measurements did not change significantly in the time between the two studies. Also, despite the greater efficiency of the dust sampler used in the full CAP Study, the dust loading house geometric means did not all increase. In fact, the dust loading results for House 51 were usually lower in the CAP Study than the Pilot Study. Across the various sample types, only the air ducts had an average decrease in dust loadings. The greatest geometric mean increase in dust loading, 9.5 times, occurred for vacuum

floor samples. Since the CAP Study only collected wipe samples from abated houses, only three houses had wipe sampling results from both the Pilot and full studies. The lead loading results in those houses were lower in the full CAP Study.

It was noted above that a more efficient dust vacuum sampler was utilized in the CAP Study. When revisiting the Pilot houses in the CAP Study, an attempt was made to collect dust samples from the same room and component. Figure 7-4 presents a comparison of the dust loading results from these two studies. The dust loading results for the Pilot Study are plotted versus those for the CAP Study. The different sample types are indicated by individual plotting symbols. The cloud of points and their location are somewhat surprising. Given the greater efficiency of the sampler used in the CAP Study, one might have expected the CAP Study dust loadings to be consistently higher than the Pilot Study results. Evidently, other factors such as

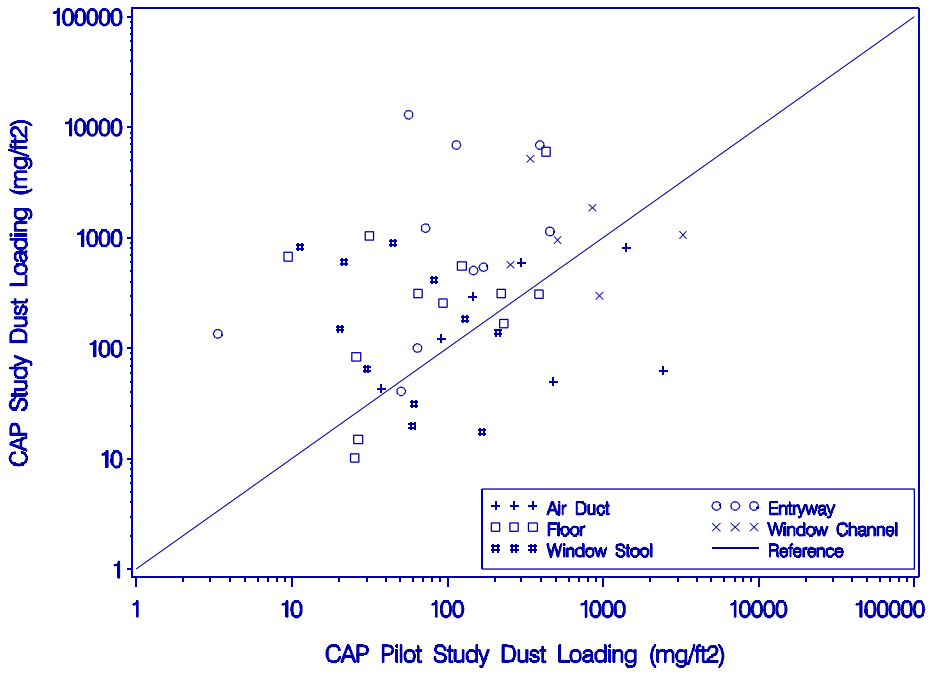

Figure 7-4. Comparison of CAP Pilot Study and CAP Study results: component geometric mean dust loadings (mg/ft^2) by sample type.

time, occupancy, and sample-to-sample variation are just as important as sampling efficiency for determining the dust loading.

7.2 COMPARISON OF CAP STUDY DATA AND HUD ABATEMENT DEMONSTRATION DATA

The HUD Abatement Demonstration project included an assessment of the extent to which lead-based paint was present in approximately 300 residential housing units. Houses selected for abatement of lead-based paint had dust samples collected from individual components within a room primarily after abatement, and soil core samples collected on all four sides of the house (both before and after the abatement). The HUD Demonstration pre-abatement samples were collected between August and December 1989. The post-abatement samples were collected between November 1989 and July 1990. The CAP Study results, in turn, were obtained in March and April 1992. Though a seasonal effect may be influencing the comparisons that follow, it cannot be separated from other differences between the projects such as sampling protocols.

Figure 7-5 illustrates the observed CAP Study lead loadings versus HUD Demonstration pre-abatement lead loadings for floor, window channel, and window stool samples. Different symbols are used for each sample type, including wipe and vacuum floor samples. Figure 7-6 illustrates the corresponding results for foundation soil lead concentrations.

Table 7-1 displays the results of a comparison of pre- and post-abatement measures collected during the HUD Demonstration. Results are restricted to floor, window channel, and window stool dust lead loadings and foundation soil lead concentrations. The top half of the table portrays statistics concerning the ratio of CAP results to pre-abatement HUD Demonstration measures; the bottom half of the table compares HUD Demonstration short-term post-abatement measures with the CAP results.

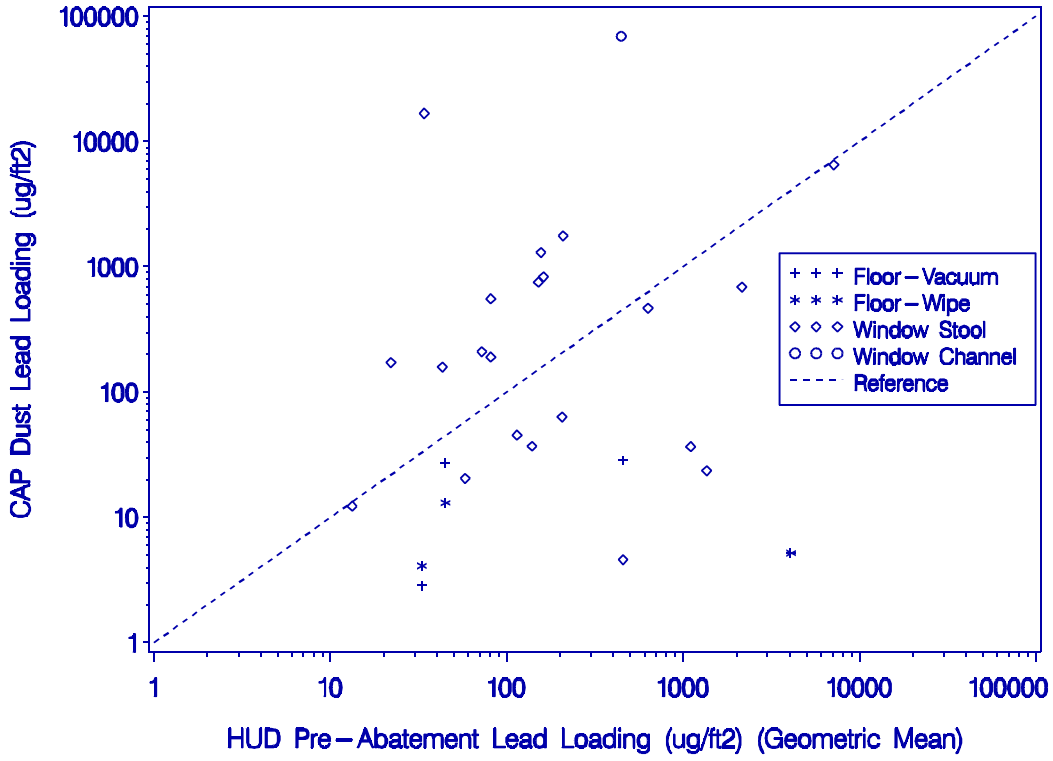

Figure 7-5. CAP versus HUD Demonstration pre-abatement lead loadings: floor, window channel, and window stool dust.

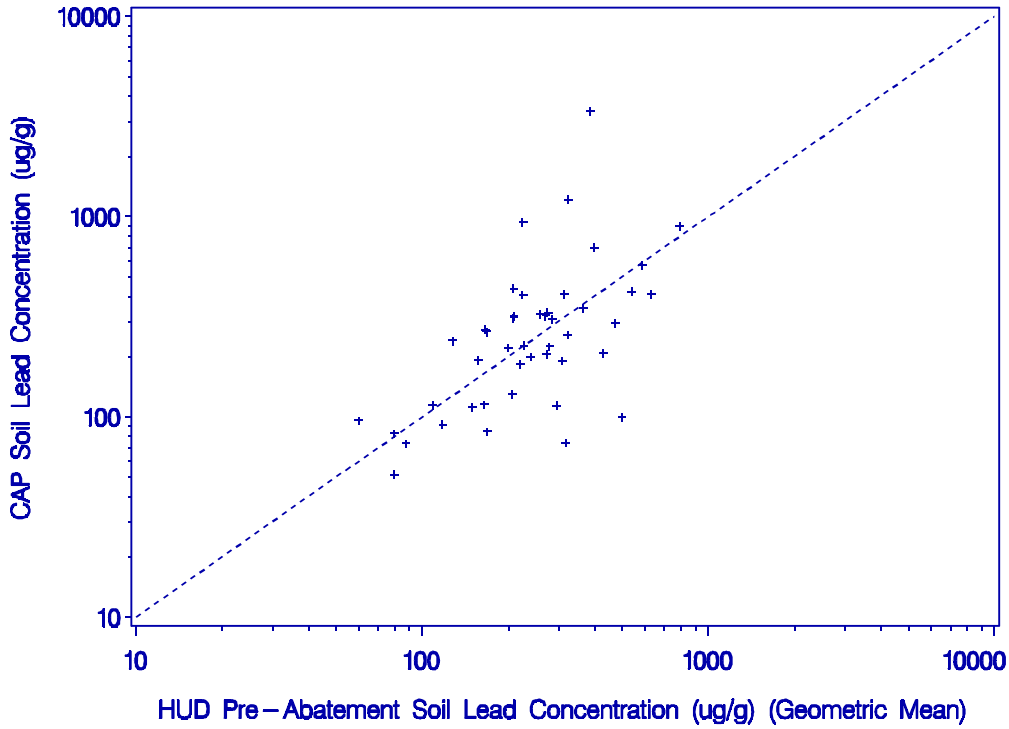

Figure 7-6. CAP versus HUD Demonstration pre-abatement lead concentration: foundation soil.

Table 7-1. Comparison of CAP Lead Levels with HUD Demonstration Pre- and Post-Abatement Lead Levels

Ratio of CAP Lead Levels to Pre-Abatement HUD Demonstration Lead Levels					
Sample Type	N	Geometric Mean	Lower Bound	Upper Bound	Signifi-cance
Floor Dust Lead Loading	7	0.04	0.004	0.41	.01
Window Stool Dust Lead Loading	21	1.14	0.37	3.46	.81
Foundation Soil Lead Concentration	45	1.02	0.83	1.24	.88
Ratio of CAP Lead Levels to Post-Abatement HUD Demonstration Lead Levels					
Sample Type	N	Geometric Mean	Lower Bound	Upper Bound	Signifi-cance
Floor Dust Lead Loading	147	1.21	0.87	1.68	.26
Window Channel Dust Lead Loading	38	40.4	19.5	83.9	<.01
Window Stool Dust Lead Loading	67	2.77	1.45	5.28	<.01
Foundation Soil Lead Concentration	68	0.88	0.75	1.03	.12

This table demonstrates that there were relatively few pre-abatement samples available for comparison. Only one pair of window channel samples was comparable, and therefore window channel results were not compared in this table. In addition, there were only seven floor samples collected in the CAP Study for which a corresponding pre-abatement lead level was available. Of these seven CAP study floor samples, four were collected by wipe and three were collected by vacuum. Thus, only the results

for window stools and foundations should be used to form conclusions about the direct effect of abatement.

The ratios for window stool lead loading were more variable than the ratios for foundation lead concentration, but neither mean ratio was significantly different from one. The geometric mean ratio of lead loadings observed in the CAP Study to corresponding pre-abatement levels on window stools was 1.14, with a 95 percent confidence interval of 0.37 to 3.46. This is based on 21 samples from 10 houses.

For foundation soil, the geometric mean ratio of lead concentration in the CAP Study to pre-abatement levels was 1.02, based on 45 samples from 24 houses. This has a 95 percent confidence interval of 0.83 to 1.24. Both of these results imply that pre-abatement and CAP results were not significantly different.

More data was available to assess ratios of CAP lead loadings to HUD post-abatement lead loadings. These ratios were generally higher than those for pre-abatement lead loadings. Specifically, the geometric mean ratio of lead loading in the CAP Study to HUD post-abatement levels was 40.4 for window channels. For window stools, the ratio was 2.77.

Figure 7-7 contrasts the CAP Study floor dust lead loading ($\mu g/ft^2$) results to post-abatement results from the HUD Demonstration. For the CAP Study, geometric mean dust lead loadings are calculated for all floor dust vacuum and wipe samples collected within a room and house. Since the post-abatement dust samples collected in the HUD Demonstration project were part of the clearance procedure, only the final floor dust wipe sample collected in a room was retained. Figures 7-8 and 7-9 present similar comparisons for window stools and window channels, respectively. Recall that in the CAP Study, dust wipe samples were collected only on the floors of abated houses. As is evidenced in the figures, there is little agreement between the CAP Study results and those from the HUD Demonstration. The

higher dust lead loadings from the CAP Study, most apparent for the window channel samples, may be due to increased lead concentration in the dust, the greater efficiency of the vacuum

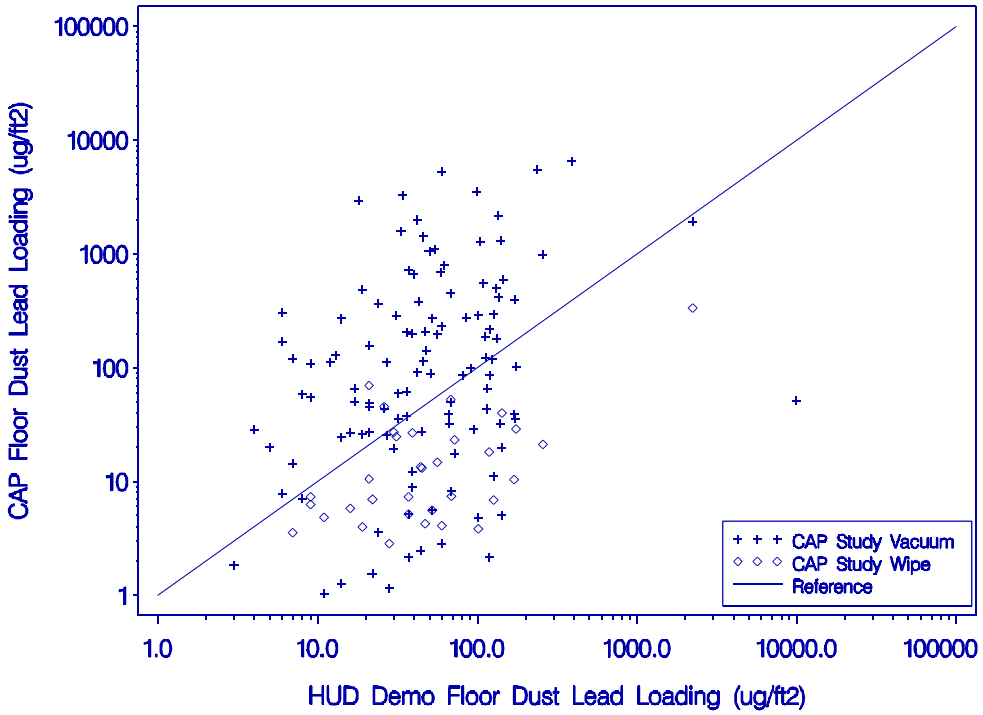

Figure 7-7. CAP vacuum and CAP wipe vs HUD Demonstration wipe results: geometric mean floor lead loading by room.

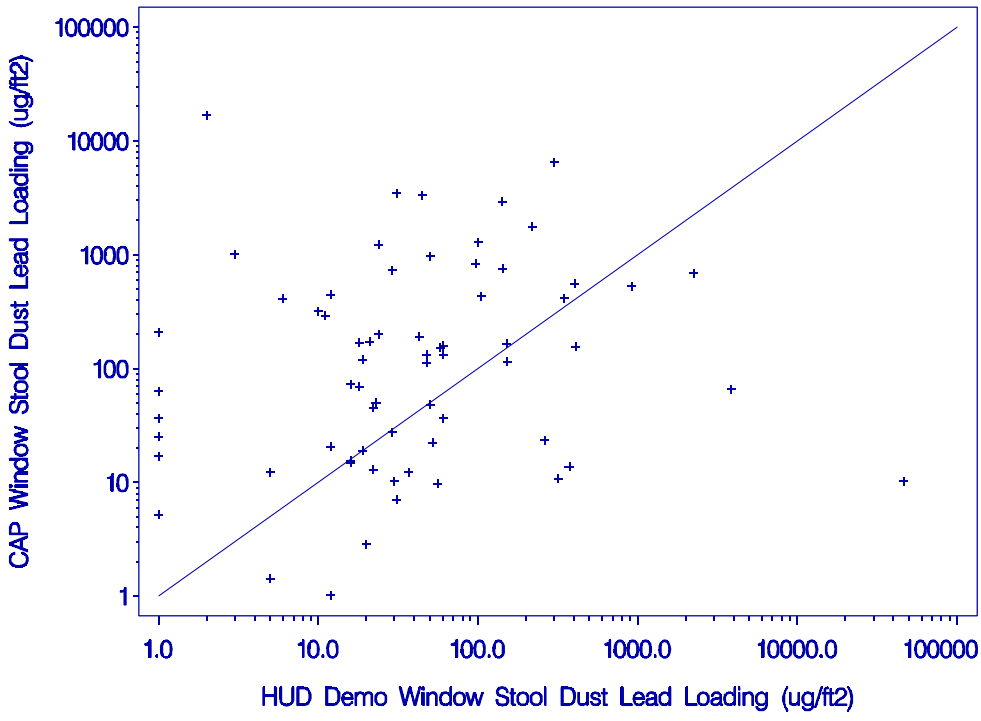

Figure 7-8. CAP vacuum versus HUD Demonstration wipe results: geometric mean window stool lead loadings by room.

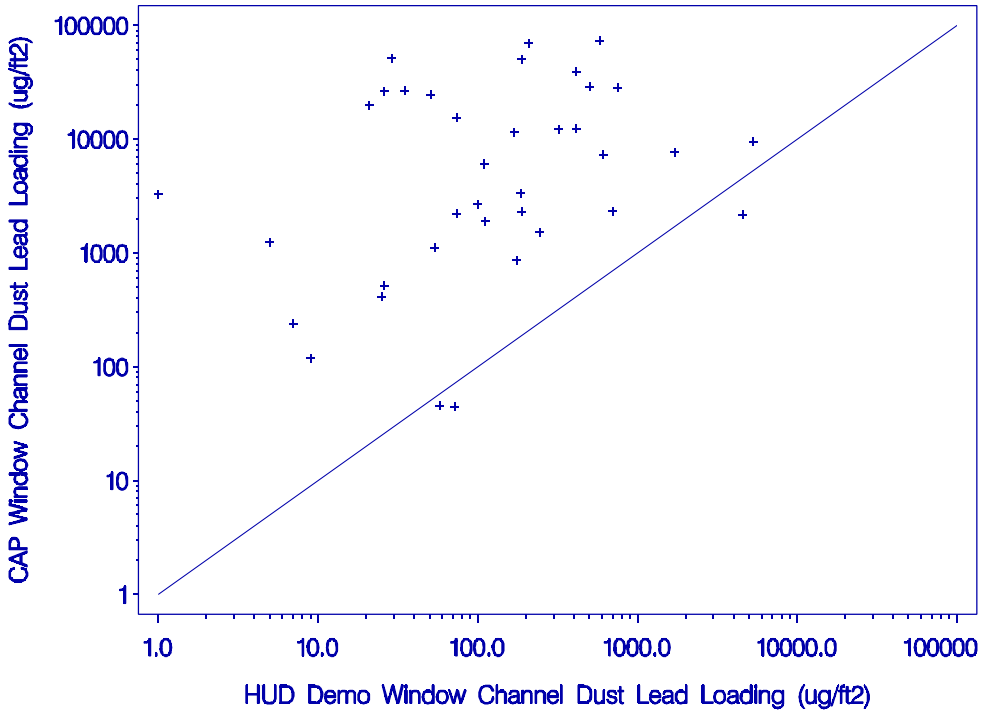

Figure 7-9. CAP vacuum versus HUD Demonstration wipe results: geometric mean window channel lead loading by room.

For purposes of comparison, a geometric mean XRF/AAS result (mg/cm^2) was calculated by room and house from the extensive HUD Demonstration XRF/AAS measurements within the room. Figure 7-10 compares the CAP Study floor dust lead loading results (both wipe and vacuum) and the HUD Demonstration dust wipe lead loadings to these room geometric mean XRF/AAS results. Similar comparisons are portrayed for window stools (Figure 7-11) and window channels (Figure 7-12). The resulting clouds of points suggest little or no correlation between dust lead loading and the XRF/AAS results for both the HUD Demonstration and the CAP Study projects. The scatter is somewhat more pronounced at lower XRF paint-lead loadings. Higher dust lead loadings are at times evident for the CAP dust vacuum samples and again particularly so for the window channel results.

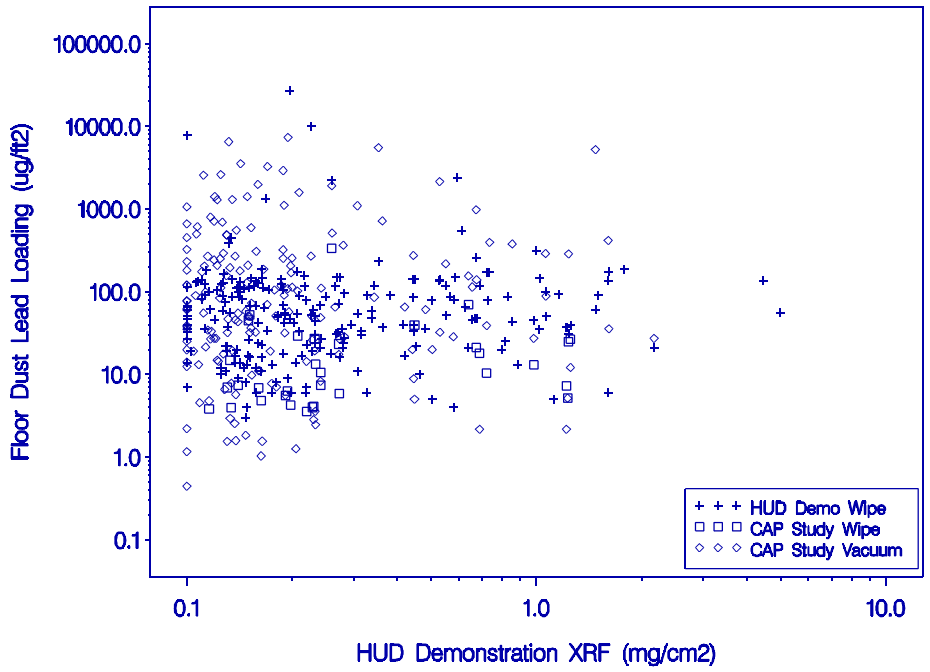

Figure 7-10. CAP wipe, vacuum, and HUD Demonstration wipe versus HUD Demonstration XRF/AAS results: geometric mean floor lead loading (µg/ft^2) by room.

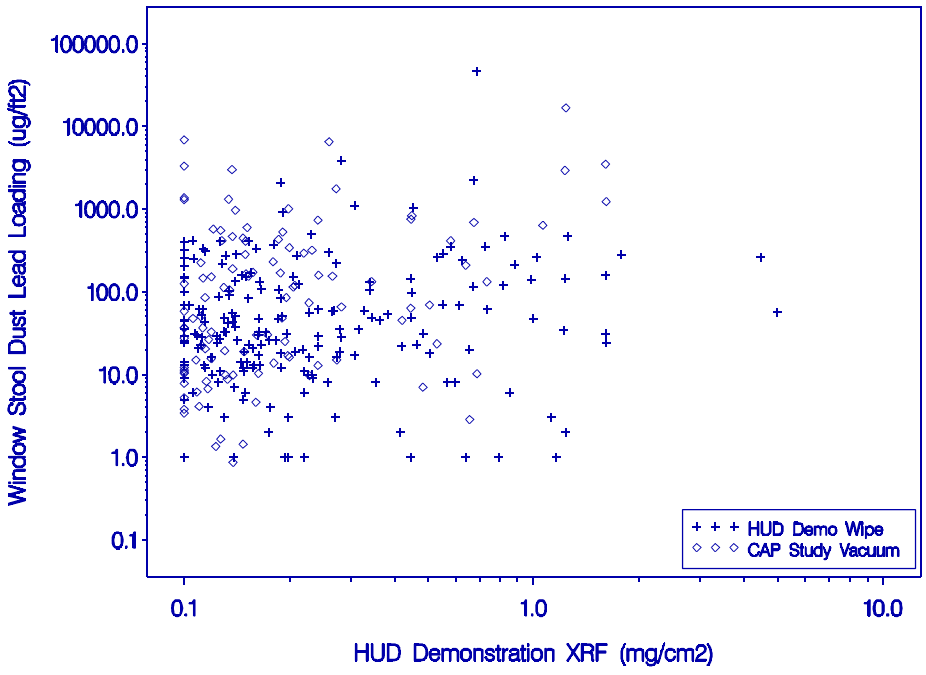

Figure 7-11. CAP vacuum and HUD Demonstration wipe versus HUD Demonstration XRF/AAS results: geometric mean window stool lead loading (µg/ft^2) by room.

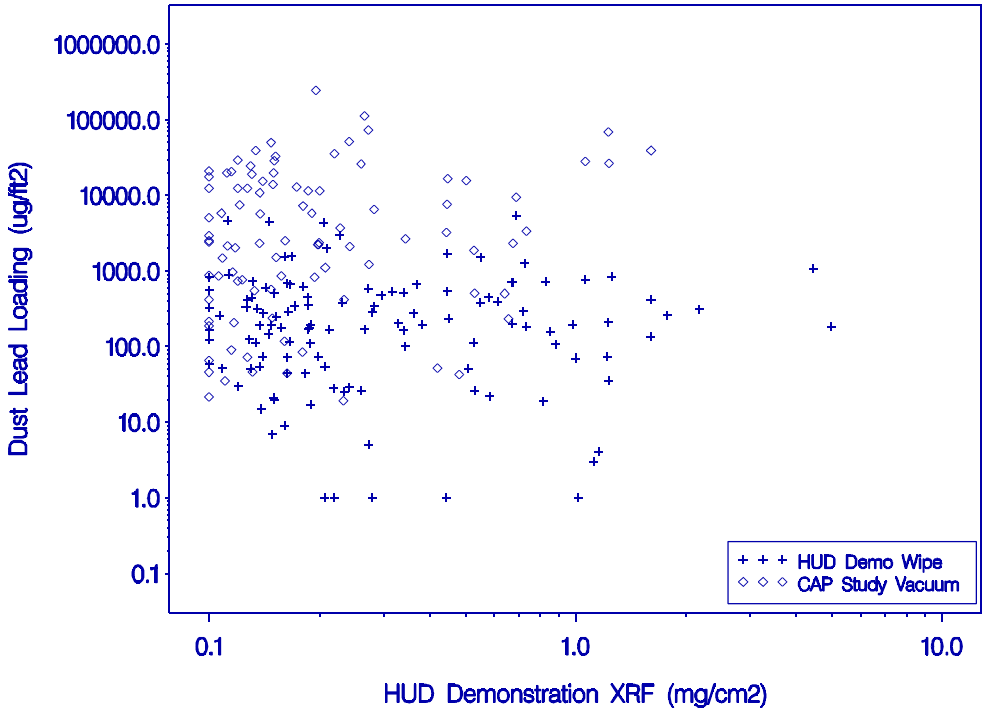

Figure 7-12. CAP vacuum and HUD Demonstration wipe versus HUD Demonstration XRF/AAS results: geometric mean window channel lead loading (µg/ft²) by room.

Figure 7-13 compares the HUD Demonstration and CAP studies relative to soil lead concentrations (µg/g), collected at the foundation on the same side of the house. The pre-abatement soil samples are also included as a basis of comparison. The HUD Demonstration pre- and post-abatement results appear positively correlated. The CAP soil lead concentrations, in contrast, exhibit a higher degree of scatter than the pre-abatement results.

In Figure 7-14, soil lead concentrations (µg/g) are plotted versus the HUD Demonstration XRF/AAS paint-lead loadings (mg/cm²), measured for the adjacent exterior wall. As was noted earlier in Section 4.2.2.2 (Figure 4-8), there was a significant association between the CAP soil lead concentrations and the HUD Demonstration XRF/AAS results when abated and unabated houses were considered separately. The HUD Demonstration pre-abatement soil results did not appear to exhibit any trend with increasing paint-lead loading, however. The HUD post-abatement soil results were positively correlated with paint-lead loading (.29, p=.03).

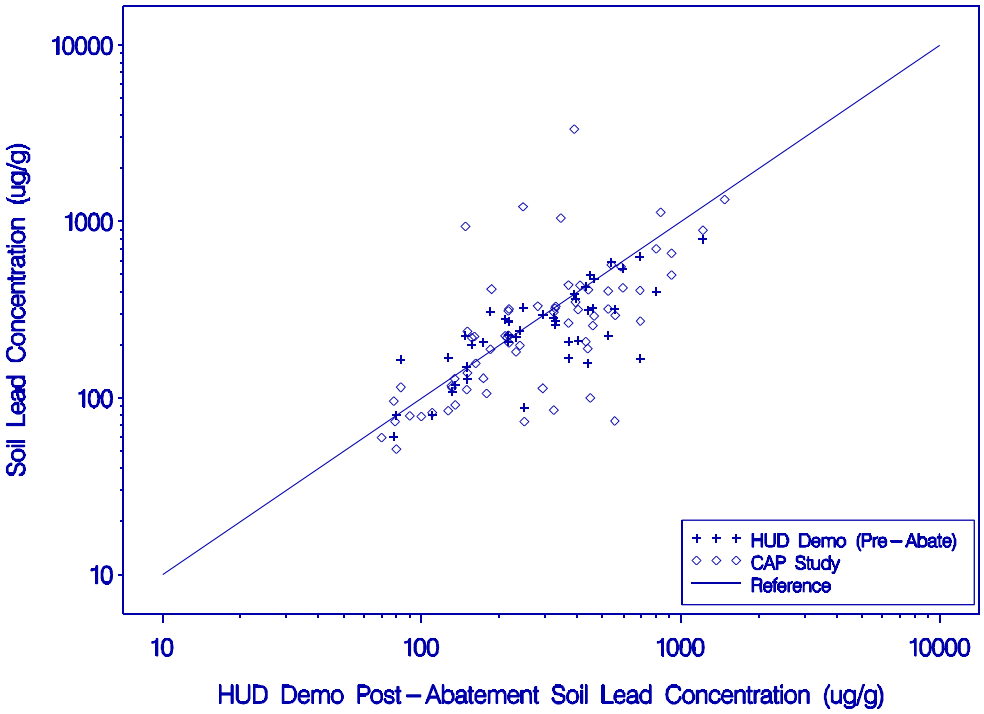

Figure 7-13. CAP versus HUD Demonstration results: geometric mean foundation soil lead concentration (µg/g) by side of unit.

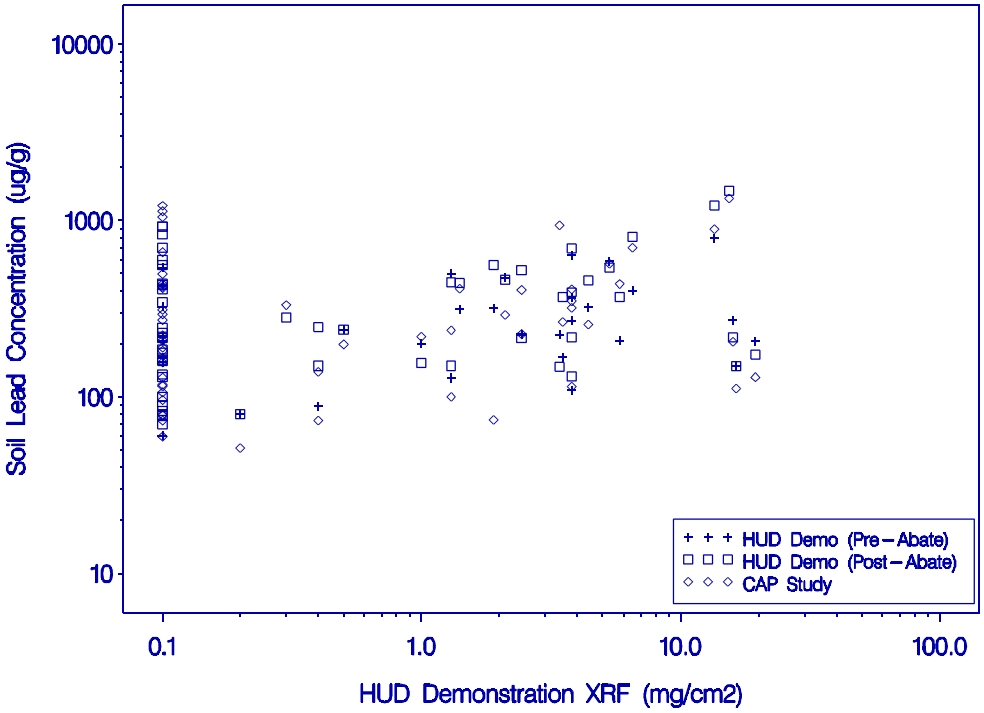

Figure 7-14. CAP soil concentration (µg/g) and HUD Demonstration soil concentration (µg/g) versus HUD Demonstration XRF/AAS results: geometric mean by side of unit.

7.3 COMPARISON OF DUST LEAD LOADINGS BETWEEN THE CAP STUDY AND OTHER STUDIES

It is useful to contrast the CAP Study dust lead loading results with those from other comparable studies, including the HUD Demonstration Study. Though considerable differences exist in the sampling frames, collection procedures, and instrumental analyses used in each study, the respective lead loading results may still provide insight on the range of environmental lead levels which exist in U.S. housing. The following four field studies were examined:

- HUD Abatement Demonstration Study,
- HUD National Survey of Lead-Based Paint,
- Kennedy-Krieger Traditional versus Modified Practices Study, and
- Kennedy-Krieger Experimental Abatement Practices Pilot Study.

The dust lead loading results for these studies were either calculated from available datasets or extracted from reported results in the scientific literature. Note that in the previous section, comparisons with the HUD Demonstration data were restricted to abated houses in Denver that were also in the CAP Study. In this section, results for all abated houses for all cities in the HUD Demonstration are used.

The comparison produced two primary results. First, the floor and window stool lead loading levels measured in the CAP Study were generally lower than those in the other studies except the National Survey. Second, the CAP Study window channel lead loadings were higher than the clearance levels measured in the HUD Demonstration and the post-abatement levels collected in the Experimental Practices Pilot.

Table 7-2 compares the CAP Study floor dust lead loading results for unabated and abated houses to those measured in the four studies listed above. For each study, the number of

Table 7-2. Descriptive Statistics for Floor Dust Lead Loadings (µg/ft²) by Abatement Efficacy Field Study

Study		Unit Type	No. of Samples Collected	Log St.Dev.[1]	10%	25%	Geom. Mean	75%	90%
CAP		Unabated	51	2.12	1.09	5.71	21.38	64.99	289.2
		Abated	187	2.00	1.69	6.73	28.97	104.34	408.6
HUD Demo[2]			1026	1.53	9.31	23.55	66.01	185.06	468.0
National Survey		High XRF[3]	686	1.85	0.14	0.42	1.47	5.13	15.80
		Low XRF[4]	90	1.63	0.06	0.16	0.47	1.41	3.78
Kennedy-Kreiger[5]	Pre-Abate.	Traditional	280	na	na	na	250.8	na	na
		Modified	82	na	na	na	288.0	na	na
	Post	Traditional	271	na	na	na	1440.0	na	na
		Modified	50	na	na	na	650.3	na	na
	Post (6 months)	Traditional	234	na	na	na	315.9	na	na
		Modified	57	na	na	na	315.9	na	na
Kennedy-Kreiger[6]	Pre	Experimental	70	na	na	na	520.26	na	na
	Post	Experimental	70	na	na	na	130.06	na	na
	Post (6 m)	Experimental	63	na	na	na	55.74	na	na

[1] Units are Log(µg/ft²).

[2] Abated houses from all metropolitan areas in the FHA portion.

[3] Predicted maximum interior or exterior XRF reading at these residences was at least 1.0 mg/cm².

[4] Predicted maximum XRF reading at these residences was below 1.0 mg/cm².

[5] Farfel and Chisolm (1990).

[6] Farfel and Chisolm (1991).

samples, log standard deviation, geometric mean, and 10th, 25th, 75th, and 90th percentiles are presented. Only the number of samples and geometric means were available for two of the studies reported in the literature. Tables 7-3 and 7-4 provide similar comparisons for window stool and window channel dust lead loadings, respectively.

The HUD Demonstration intended to eliminate lead-based paint from housing environments either by containing the lead-based paint with encapsulation or enclosure methods, or by eliminating the lead-based paint with removal methods (HUD, 1991). Because of the diversity of housing components containing lead-based paint, it was generally true that no single abatement method could be used uniformly throughout a given housing unit. The housing units selected for complete abatement included 169 single-family dwellings from the inventory of FHA repossessed houses in seven urban areas. The clearance (immediately post-abatement) dust wipe lead loading results from these houses were considered in this instance. The tabled results were calculated from all metropolitan areas in the study, not just Denver. The geometric mean floor and window stool lead loadings measured in the HUD Demonstration were higher than those collected in unabated houses in the CAP Study. In contrast, the geometric mean window channel lead loadings were lower in the HUD Demonstration than the CAP Study.

The HUD National Survey was conducted to examine on a national basis the incidence of lead in soil, dust, and paint (HUD, 1990a; EPA, 1995c; EPA, 1995d; EPA, 1995e; data revision Westat, 1993). No abatement procedures were performed. In seeking to represent the pre-1980 housing stock in the U.S., a total of 381 housing units were sampled: 284 privately-owned residences and 97 public housing units. Dust vacuum lead loading results were obtained from a subset (265 houses) of the privately-owned residences sampled and were included in Tables

7-2, 7-3, and 7-4. The houses were partitioned into two groups: the high XRF group with a predicted maximum of interior or

Table 7-3. Descriptive Statistics for Window Stool Dust Lead Loadings (µg/ft²) by Abatement Efficacy Field Study

Study		Unit Type	No. of Samples Collected	Log St.Dev.[1]	10%	25%	Geom. Mean	75%	90%
CAP		Unabated	35	1.93	3.79	9.85	46.90	224.7	571.5
		Abated	78	2.18	7.02	15.43	91.57	467.2	1315.1
HUD Demo[2]			783	1.79	9.03	26.70	89.06	297.1	878.56
National Survey		High XRF[3]	329	2.47	0.18	0.82	4.32	22.77	101.74
		Low XRF[4]	38	2.47	0.05	0.24	1.26	6.68	29.98
Kennedy-Kreiger[5]	Pre-Abate.	Traditional	280	na	na	na	1337.8	na	na
		Modified	82	na	na	na	1802.3	na	na
	Post	Traditional	271	na	na	na	3595.4	na	na
		Modified	50	na	na	na	603.9	na	na
	Post (6 months)	Traditional	234	na	na	na	1542.2	na	na
		Modified	57	na	na	na	1635.1	na	na
Kennedy-Kreiger[6]	Pre	Experimental	70	na	na	na	4608.0	na	na
	Post	Experimental	70	na	na	na	325.2	na	na
	Post (6 m)	Experimental	63	na	na	na	408.8	na	na

[1] Units are Log(µg/ft²).

[2] Abated houses from all metropolitan areas in the FHA portion.

[3] Predicted maximum interior or exterior XRF reading at these residences was at least 1.0 mg/cm².

[4] Predicted maximum XRF reading at these residences was below 1.0 mg/cm².

[5] Farfel and Chisolm (1990).

[6] Farfel and Chisolm (1991).

Table 7-4. Descriptive Statistics for Window Channel Dust Lead Loadings (µg/ft²) by Abatement Efficacy Field Study

Study		Unit Type	No. of Samples Collected	Log St.Dev.[1]	10%	25%	Geom. Mean	75%	90%
CAP		Unabated	27	2.02	84.16	738.0	2330	12427	20517
		Abated	71	2.33	51.74	510.5	2590	18884	39308
HUD Demo[2]			756	1.93	42.90	138.1	506.2	1856	5973
National Survey		High XRF[3]	142	2.66	2.40	12.08	72.64		2194
		Low XRF[4]	7	3.38	0.38	2.97	28.94	436.72	2193
								282.33	
Kennedy-Kreiger[5]	Pre-Abate.	Traditional	280	na	na	na	15496	na	na
		Modified	82	na	na	na	18274	na	na
	Post	Traditional	271	na	na	na	14354	na	na
		Modified	50	na	na	na	8083	na	na
	Post (6 months)	Traditional	234	na	na	na	12468	na	na
		Modified	57	na	na	na	24879	na	na
Kennedy-Kreiger[6]	Pre	Experimental	70	na	na	na	29422	na	na
	Post	Experimental	70	na	na	na	938	na	na
	Post (6 m)	Experimental	63	na	na	na	1003	na	na

[1] Units are Log(µg/ft²).

[2] Abated houses from all metropolitan areas in the FHA portion.

[3] Predicted maximum interior or exterior XRF reading at these residences was at least 1.0 mg/cm².

[4] Predicted maximum XRF reading at these residences was below 1.0 mg/cm².

[5] Farfel and Chisolm (1990).

[6] Farfel and Chisolm (1991).

exterior XRF levels of at least 1.0 mg/cm^2, and the low XRF group with a predicted maximum of interior and exterior XRF readings of less than 1.0 mg/cm^2. There were 235 houses in the high XRF group and 30 houses in the low XRF group. The unusually low dust lead loadings measured in the National Survey may be misleading, due in part to the sampling apparatus employed. Vacuum versus wipe field testing by EPA (EPA, 1995a) indicated that the vacuum sampling protocol used in the National Survey recovered only about 20% of the lead that would be recovered by a wipe sample. Wipe sample results tended to be less than or equivalent to those from the CAPS vacuum sampler. Hence there is likely to be at least a five fold difference between CAPS vacuum dust results and National Survey vacuum dust results, which would account for some of the differences in lead loadings between the CAP Study and the National Survey.

The Traditional versus Modified Practices Study was performed by Kennedy-Kreiger Institute (Farfel and Chisolm, 1990). Serial dust wipe lead loading measurements were collected from 71 dwellings in Baltimore, Maryland. Samples were collected before, immediately after, and six months after abatement of lead-based paint within the dwellings. Local abatement requirements addressed deteriorated paint on surfaces up to four feet from the floor and all paint on easily accessible "biting" surfaces where lead content of the paint was greater than 0.7 mg/cm^2 by XRF or 0.5 percent by weight. Traditional practices involved only cursory clean-up following the abatement, and allowed a variety of abatement methods to be used. The modified practices called for more substantial clean-up following abatement, and excluded the use of open-flame burning and sanding techniques. Most of the study dwellings were low-income row houses constructed before 1940. The geometric mean floor, window stool, and window channel dust lead loadings in the CAP Study were at least an order of magnitude lower than the geometric mean post-abatement values for both the traditional and modified

practices procedures. The incomplete nature of the traditional and modified abatement procedures may explain the resulting high dust lead loadings. Window channels, for example, were not abated as part of these procedures.

The Experimental Practices Pilot Study was also performed by Kennedy-Kreiger Institute (Farfel and Chisolm, 1991). The experimental practices are described as abatement procedures which included, (1) treatment of lead-painted surfaces above and below four feet from the floor; (2) sealing and covering of wooden floors; (3) procedures for containment of dust during abatement; and (4) final cleanup using a high-efficiency particle air (HEPA) vacuum. Dust wipe lead loading samples were collected in six two-story, six-room low income row houses constructed in the 1920's. Measurements were taken before, immediately following, and six months after the abatement procedures occurred. The CAP Study geometric mean lead loading levels measured on floors and window stools were lower than those measured following the experimental abatement procedures. Interestingly, the geometric mean window channel lead loadings in the CAP Study were higher than the post-abatement results in the Experimental Practices Pilot. It should be noted that the CAP Study took place two years after abatement, while the Experimental Practices results were within six months of abatement.